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# **Similarities and Differences in Barrel Vaults of Traditional and Stately Houses in the Historic Centre of Arequipa, Perú**

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## **INTRODUCTION**

The traditional architecture of the centre of the city of Arequipa has been analyzed by comparing floor-plans of houses from the eighteenth and nineteenth centuries in order to explain the reasons behind the arrangement of their constructional elements and the evolution of said elements and floor-plans.

The historic centre of Arequipa, a city located in the South of Perú, South America (Latitude 16°23' South, Longitude 71°31' West), is based on a ground plan from 1540 that was set during the city's Spanish foundation. It was declared Patrimony of the Humanity by UNESCO. The manorial architecture is widely known for its decorated fronts and one-of-a-kind designs, but its differences with respect to the popular architecture are not based exclusively on decorative aspects.

Peru's colonial period finished around 1825, but the barrel-vault, construction style continued in Arequipa through 1868, when an earthquake destroyed the city. Thereafter, the vaults were replaced by roofs made of rails, with cinders made out of the lava stone.

The stately houses belonged to the founding families who settled around the main square on forty nine blocks that formed a square-grid, street layout. Also belonging to this category are the houses of landlords and traders from post-colonial times.

## **STATE OF THE ART**

Studies performed on Arequipa's architecture explain the contribution of the conqueror and the conquered. "It is a real and true fusion, it is the perfect colourful architecture, considered the most complete of the mestizo architectures developed in America" (Málaga: 1983). From the artistic viewpoint, the decoration of the fronts of churches and manorial houses is relevant. It does not protrude in bulk, but is "flat" (San Cristóbal: 1997). And there are close bonds in the motives which decorate the fronts of the churches and the manorial houses (Tord: 1987).

Chronologically "the Arequipa house in the XVI century is characterized by its straw roofs; in the XVII, by tile roofing, and in the XVIII and XIX centuries by the lava-stone vault". Furthermore, "various factors influenced the shape of Arequipa's civil architecture, among them the geography,

represented by earth tremors, the lack of wood, the rains and the ground profile, as well as the clean atmosphere together with a bright luminosity; these allowed the formation of a type of truly-genuine, civil construction" (Quiroz Paz Soldán: 1983).

Elements in the streets of Arequipa have been found to be similar to those of streets in Priego de Córdoba, Fuentes de Andalucía, Ayamonte, etc.: "we see numerous architectural details from the named Andalusian villages appearing in the Peruvian cities, ornamental ironworks, splays of windows (the most typical of the Andalusian baroque), balconies, towers and tile roofs." (Noel: 1921).

Finally, "Arequipa had to renew its urban landscape also after the damages inflicted by the earthquakes of 1604 and 1687. The use of stone vaults, which had been practised in temples, was transferred to the civil architecture" (Gutiérrez: 1990).

## CONSTRUCTIONAL INVARIANTS

The first approach to this subject is that over approximately three centuries, a construction system based on arches and tunnel vaults was used to erect all kinds of buildings: churches, bridges, mills, houses, lodgings, wayside inns, workshops, etc.

This unity of material and barrel-vault construction system is an invariant of the religious, manorial and popular Arequipa architectures, which gave them an identity and differentiated it from the rest of the Peruvian, and even Spanish, architectures.

### The proportions of the internal construction space

Without considering the length of the naves or rooms, but considering the dimensions of the vaults and the interior heights, we have distances (D) between walls of 8 to 10 m in churches, 5 to 6 m in manorial houses and 4 m in popular houses. Likewise, the heights of the walls to the impost, equal approximately the spring line in most of them. But the spring line of the vaults in popular houses is slightly less than half the distance between the supporting walls, so those vaults are not quite semicircular.

Therefore, the application of the construction system with vaults to these three types of buildings provides a ratio:

$$\text{popular} : \text{manorial} = \text{manorial} : \text{religious} = 1 : 1.5$$

So, we can apply a factor of 1.5 to determine the dimension of spans and heights of the interiors, and compare the ratios between the manorial houses with respect to the popular houses (**Fig. 1**), and the naves of churches with respect to rooms in manorial houses (**Fig. 2**).

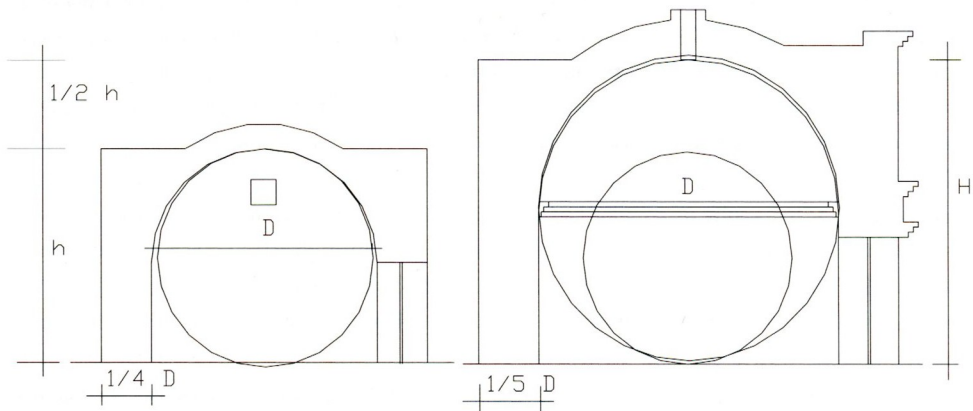


Figure 1. Internal proportions between a popular house and a stately house

On the other hand, the following rule applies to the walls of popular houses: the width of the buttress equals one quarter of the distance between supports (Blondel:1683). Then, for spans from 4.00 m to 4.30 m, the walls are at least 1 m thick. Likewise, this rule also applies to churches, since for spans of 8.50 m the walls are more or less 2 m thick, without including the buttresses. In manorial houses, not all of the walls are equally thick, and most of them are one fifth the distance between supports (Figs. 1 and 2).

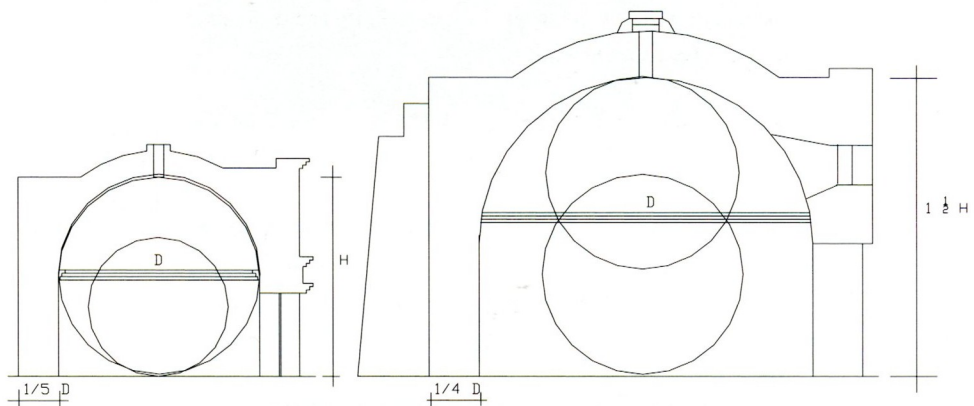


Figure 2. Internal proportions between a stately house and a colonial church

### The multi-functional material

Since it is easy to cut and work with the volcanic-lava stone, it became the multi-functional material used for walls, floors, pavements, drain channels, decorative elements, etc. The rest of the materials had more specific uses: wood for floorings, doors and windows; iron for grates; lime for mortars and paints; and brick for interior pavements and some vaults in manorial houses.



Certainly, the stereotomy of stone is most varied in religious architecture, but the dimensions of haunches and stone blocks ( $40\text{ cm} \times 30\text{ cm} \times 20\text{ cm}$ ) are the same in all constructions. The variable is the width of the core (the area filled with rounded stones) that is inserted between the two vertical sets of stone blocks that comprise the wall. Also, the filling (which includes sand, lime and gravel) over the extrados is thicker in vaults with larger spans.

The thickness of the vaults of popular homes is 50 cm. It is 80 cm in manorial houses, and this includes the thickness of the haunches, which is no greater than 20 cm because they are placed “horizontally” rather than “vertically” in a format that the Spanish refer to as “a tabla”. (Figs. 3 & 4). Some vaults, mostly in manorial homes, have their keystones placed vertically, although a common practice was to build vaults with an even number of haunches. In all cases, the line of force falls within the thickness of the arches or vaults. Sudden or gradual collapse has been caused mainly by the earthquakes that affect this side of the Pacific Ocean, and not by the thickness of the haunches.



Figure 3. Type of haunches of a barrel vault.



Figure 4. Keystone of the lintel with the year of construction (1795)

## DIFFERENCES BETWEEN STATELY AND POPULAR ARCHITECTURE

In the first place, popular homes are not only built on the city blocks farthest from the original core (Villalba, Cruz Verde, Puente Grau Streets), but also in the immediate surroundings of the manorial houses. This took advantage of the division of the plots, including those belonging to established religious orders. Therefore, the homes have occupied empty spaces and increased the density of the historic centre.

Secondly, the popular house is erected on a smaller plot, 500 m<sup>2</sup>, which is approximately one third of the area of the manorial home. This results in a narrower façade, smaller rooms, varied arrangements of the vaults on the ground plan, and no orchard in the smallest homes. It should be said that, with some exceptions, the popular home does not have the loggia with rib vaults (usually placed on the second patio of the manorial houses) (Fig 5c).

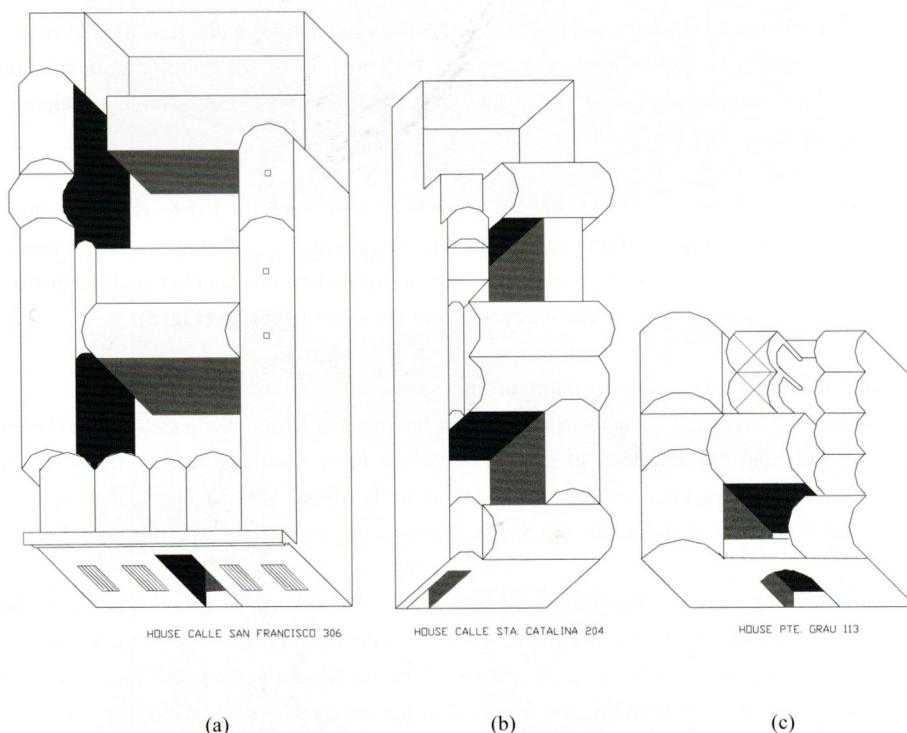


Figure 5. Houses of different sizes: with two large courtyards, with small courtyards and only one courtyard without corridor of entrance.

Thirdly, the identification of the ornament on the front façade is not the only element to study when dating or identifying the buildings. The constructional differences of the vaulting are also relevant.

### **The contention of vaults' thrust forces**

In colonial homes, the vault over the front entrance hall is placed in the centre (perpendicular to the street), and is tied by two vaults perpendicular to it. As a result, their buttresses become part of the façade. This makes it possible to eliminate the end wall at the patio side, and partially the one on the façade, where the front door is placed. The second hall or "chiflón", also vaulted (**Fig. 11**), lacks end walls and is generally placed on one side, left or right, of the house. In some popular houses it has no roof or vault.

Nevertheless, in popular houses and post-colonial ones, with narrower fronts, the traditional arrangement was modified, by building some or all front vaults either perpendicular or parallel to the hall vault. But the most noticeable modification is the elimination of the entrance hall, i.e. the transition street-hall, so one enters directly a patio (e.g. Puente Grau street houses, **Fig. 5 c**). In this case the door lintel, basket arch, replaces the barrel vault and withstands the thrust forces from the side vaults.

In any case, the vaulted halls have endured the earthquakes and constitute the least altered space of Arequipa's architecture. Furthermore, a room was built on top of the "chiflón" vault to take advantage of the latter's low height and it has functioned as a vault reinforcement, helping to prevent its sinking.

On the other hand, in some colonial houses small buttresses were needed to resist the thrusts generated by the vaults (**Fig. 6**). But in general the thrust forces of the vaults balance out, depending on their arrangement. They could be perpendicular or parallel to one another and act between different properties because there were no empty spaces between the houses (**Fig. 5**).

### **The buttress (abutment) façade or front of the vaults**

The façades to the street and to the interior patios are the result of harmonizing the different heights of the end walls and the buttresses of the vaults. As we have already explained, the traditional façade receives the thrust forces of the vaults parallel to the street. The vaults are filled up to the intrados, and the cornice of the façade is at the same level or higher than the extrados (**Fig. 3**).

The disposition of the two vaults parallel to the street on either side of the entrance hall originates symmetry on the façade, front door and lateral windows of the traditional design. In the houses with barrel vaults perpendicular to the street, the end walls form the façade, and bigger doors or windows can be opened in them. For example, the five vaulted houses (now stores) on Bolivar street, with individual patios in the back, for servants of the convent of Santa Catalina; the seven stores in San Agustín (1796), whose corniced façade has one gargoyle and a window above each door; or the four homes on the 28<sup>th</sup> of February Square with balconies that were restructured after the earthquake of 1960.



We could conclude that the symmetry in the composition of the façades is not achieved in many houses because either the entrance hall is on one side, or other doors are added for second storey access (**Fig. 7**). The present-day adaptations to use the homes as stores have exacerbated the lack of symmetry by converting windows to doors.



Figure 6. Colonial house with buttress and balcony over carved stone supports.



Figure 7. Post-colonial stately house with balcony and second storey.



In reality, there is an intention to hide the fronts and the buttresses in the design of the façades (**Fig. 8 and Fig. 9**). There also are very few examples of homes with a vaulted room over the entrance hall, imitating the room above the “chiflón” in colonial houses, and which modify the horizontal profile of the façade.



Figure 8. Façade of colonial, stately house



Figure 9. Typical façade of colonial, popular house

## THE DIMINISHING OF NATURAL LIGHT

Long vaults parallel to the façade or to the patios provide the possibility of having two windows each, but in the case of short vaults, this ability is reduced and the windows and doors only open in the end walls.

In any case, the fabrication of the thick stone walls has resulted in these holes being smaller than those of the brick fabricate, to avoid the use of discharge arches of greater span, because the door lintels and windows are built based on basket arches in the interior core and linteled on the exterior. (**Fig. 4**).

The difference between manorial houses and popular ones are in the quantity of light received according to the number of doors and windows. The manorial houses have larger windows and more lighting from the roof, by the skylights disposed in the keystones of the vault, if not in the superior floor. The popular houses, however, are dark because they have less windows to the inside, and the natural lighting is done by high windows placed in the end walls and also through patio doors (**Figs. 10 and 11**).

## THE FINISHINGS AND ORNAMENTS

The cut and carving of the soft stone allowed the flat decoration of the Arequipa façades, sometimes including the carving of the date of construction or last repair. Nevertheless, we should mention that carving of shields, monograms, flower and fauna on doors, lintels, vault keystones; gargoyles etc.

and of stepped horizontal supports of balconies characterize colonial houses. The popular colonial house has minimal ornament, for example, some religious icons over the doorway (**Fig. 12**), simple pillars, and cylindrical or U-shaped gargoyles.

The façade of the manorial house of the XIX century or postcolonial, is characterized by a neoclassical language on the façades, based on the carving of entablatures, paired columns placed between openings that crown in Ionic and Doric capitals and bracket of support to a future balcony, which in some cases never got built. The popular house has a façade that keeps the general scheme but is less elaborate. (**Fig. 13**).



Figure 10. Doors to courtyard of popular house.

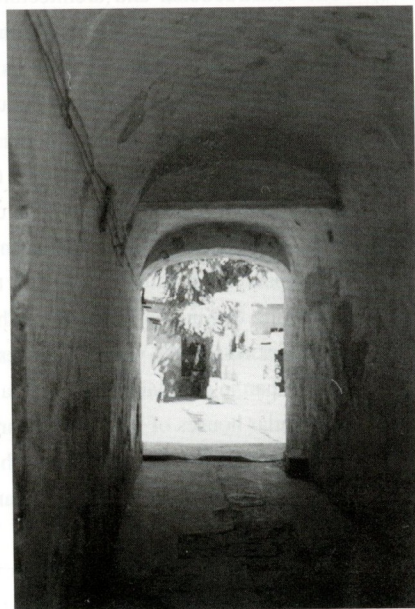


Figure 11. Secondary corridor or chiflón.



Figure 12. Colonial façade of popular house



Figure 13. Street of popular houses



In general terms the finishings are more accurate and artistic in manorial architecture, with lava-stone and rounded stone pavements, grate in the hall, doors with iron nails, windows and window shutters with better finishings, decorative paintings in interiors, stone ovens in kitchens etc. All of this contrasts with the austerity and utilitarian value of the finishings of the popular house. They all have, however, a common element: the windows protected by iron works with the traditional 8 in the centre.

## CONCLUSIONS

- a) The constructional and architectural invariants of Arequipa houses are the lava-stone material, the construction system based on barrel vaults, and the inner patio.
- b) In popular houses, the differences are conditioned by the limitations of plots that are smaller than those of manorial houses, more than by their belonging to the colonial or post colonial period.
- c) The variation of the dimension of the span of the vault and the interior height, between manorial and popular architecture, can be estimated by the ratio 1 : 1.5. As well, the ratio is the same between the religious and manorial architecture.
- d) The span of the vaults is equal to the height floor-intrados, with a tendency to diminish the spring line in popular houses. This results on barrel vaults that are slightly broadened.
- e) The thickness of the walls or buttresses that receive the thrusts of the vaults is one quarter of the span in popular houses. In manorial houses this amounts to one fifth of the span.
- f) In popular houses of the XIX century, the vaults of the halls of entrance are replaced by a discharge arch-lintel of the door, which props up the side vaults.
- g) When vaults are built perpendicular to the façade, the latter stops working as a buttress (abutment).
- h) The construction system based on thick walls originated a reduction of the number of windows, and so the reduction of the natural lighting, which is not counterbalanced by skylights in popular houses.
- i) The symmetry of the façades is clearer in manorial houses because of the rich fronts, and in any case only answers to the ground-floor composition.
- j) The analysed patrimony corresponds to a hand-made construction, so in both kinds of houses, the finishings and decorations are unique.
- k) The analysis of the types of building cannot be solely made from the viewpoint of art history, particularly the decoration of the façades, but through the study of dimensions and constructive proportions, which also determines its characterization and classification.

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